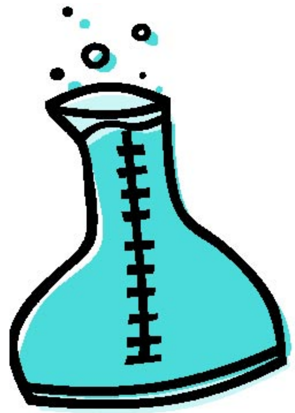
High School Chemistry

The Role of Chemistry in Fire Management



Introduction

Good morning/afternoon. I am _______________, and I work for the ___________ National Forest. My job is ______ _________________.

Lesson

How many of you have ever played ping-pong? How much more exciting would that ping-pong game be if you got to use this ping pong ball?

Activity

(Light ping-pong ball.)

Lesson Continued

That's just one example of the many chemical reactions that we as wildland firefighters study and use in our jobs.

But, before we get to the specifics of advanced fire management techniques, like flaming ping-pong balls and the chemistry behind them, let's start with the basic chemistry of fire.

In order for there to be fire – or, in other words, in order for the chemical reactions that we simply call fire to take place – there need to be three components. Each one is equally important, and if one is missing, fire will not occur.

The first component is oxygen. Nothing can burn without the presence of oxygen. The second component is fuel. Fuel can be any substance that burns. The final component is heat. Heat is what keeps the chemical reactions of fire going. Together, these

Forest Service Messages

A: The Forest Service applies the fundamental principles of science and ecology in order to better understand and manage forest ecosystems.

A-5: The study of the science of fire and its behavior is important.

B-1: People need to be careful with fire.

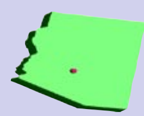
B-6: The understanding of fire suppression techniques is important.

C-5: In many places on the National Forest, conditions now are such that wildland fires can have devastating, long-lasting effects.

C-6: The Forest Service cuts trees to accomplish specific objectives within the ecosystem such as reducing the risk of wildland fire, enhancing dwindling aspen stands, restoring grasslands, and improving forest health and wildlife habitat.

C-9: Prescribed fire is one tool the Forest Service uses to meet ecosystem goals.

Academic Standards



Arizona Standards

SCIENCE

1SC-P1: Propose solutions to practical and theoretical problems by synthesizing and evaluating information gained from scientific investigations

PO 1: Evaluate scientific information for relevance to a given problem

PO 2: Propose solutions to a problem, based on information gained from scientific investigations

3SC-P1: Apply scientific thought processes and procedures to personal and social issues

PO 1: Apply scientific thought processes of skepticism, empiricism, objectivity and logic to seek a solution to personal and social issues

PO 2: Apply a scientific method to the solution of personal and social issues

5SC-P1: Predict chemical and physical properties of substances (e.g., color, solubility, chemical reactivity, melting point, boiling point)

PO 1: Describe physical and chemical properties that are used to characterize substances

PO 2: Determine physical and chemical properties of a substance through observation, measurement and three components are known as the fire triangle. (Show picture of fire triangle or draw it on the board.)

Chemically speaking:

- Fire is simply another word for combustion.
- Combustion is a rapid oxidation that is accompanied by high temperature and usually light.
- Oxidation put simply means a chemical reaction that involves combining substances with oxygen. This chemical reaction releases a lot of energy.

In order for there to be fire – or, in other words, in order for the chemical reactions that we simply call fire to take place – there need to be three components. Each one is equally important, and if one is missing, fire will not occur. These three components make up the fire triangle.

So, those are the basics of fire chemistry in general terms, but now I'd like to talk about the chemistry involved in the natural process of wildland fire.

Let's look at our fire triangle again. The first component I mentioned was oxygen. As you know, oxygen exists in the air we breathe. Oxygen is the second most common substance in the earth's atmosphere. The atmosphere contains approximately 21 percent oxygen and 78 percent nitrogen. As you can tell by your campfire, there is obviously just enough oxygen in our atmosphere to sustain a fire. If there were any less oxygen in our atmosphere, there wouldn't be enough to keep a fire going. And, we wouldn't need firefighters because most fires would immediately go out. If there was too much oxygen in our atmosphere, when you struck a match to light your campfire, the fire would spread uncontrollably and eventually burn everything in sight. It is because the atmosphere has just the right mixture of oxygen,

The smoke you see coming off of a fire is made up of tar along with water, which is escaping as steam.

experimentation

5SC-P5: Describe and predict chemical reactions (including combustion and simple chemical reactions) and physical interaction of matter (including velocity, force, work and power), using words or symbolic equations

PO 2: Predict the products of a chemical reaction using types of reactions (e.g., synthesis, decomposition, replacement, combustion)

PO 3: Describe physical interactions through use of word equations or formulae

5SC-D3: Apply knowledge and understanding of chemical and physical interactions (e.g., rates of reactions, stoichiometry, electromagnetic phenomena, statics and dynamics, electrochemistry)

New Mexico Standards

SCIENCE

Strand I: Scientific Thinking and Practice

Standard I: Understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting, and validating to think critically.

9-12 Benchmark I: Use accepted scientific methods to collect, analyze, and interpret data and observations and to design and conduct scientific investigations and communicate results.

Grade 9-12 Performance Standards

1. Describe the essential components of an investigation, including appropriate methodologies, proper equipment, and safety precautions.
2. Design and conduct scientific investigations that include:
   - testable hypotheses
   - controls and variables
   - methods to collect, analyze, and interpret data
   - results that address hypotheses being investigated
   - predictions based on results
   - re-evaluation of hypotheses and additional experimentation as necessary
   - error analysis.
3. Use appropriate technologies to collect, analyze, and communicate scientific data (e.g., computers, calculators, balances, microscopes).
4. Convey results of investigations using scientific concepts, methodologies, and expressions, including:

which allows combustion, and nitrogen, which hampers combustion, that fires on this planet burn as they do. So, the oxygen portion of our fire triangle for wildland fires comes from the oxygen in our atmosphere.

Fire Triangle

The second component of the fire triangle is fuel. Generally speaking, fuel is any material that can burn. The materials that fuel wildland fire are simply those materials that are found naturally in the forest. Specifically, in a ponderosa pine forest such as around here, these fuels are the natural duff and litter on the forest floor, the grasses and brush that grow amongst the trees, and the trees themselves. Because people have made the decision to move into the woods, homes can also be fuel for fire.

The final component of the fire triangle is heat. A wildland fire can't start without a source of heat, which we call an ignition source. A natural ignition source is lightning. On the _______ _____ National Forest where I work, the majority of our fires are started by lightning. Unfortunately, we also have to deal with human-made ignition sources such as campfires, cigarettes, vehicle exhaust systems, and fireworks. Our major goal during fire season is to prevent fires from human-made ignition sources. If we can prevent those kind of fires, then we will have more resources available to fight the inevitable lightning-caused fires.

Once one of these initial heat sources starts a wildland fire, the heat from the combustion reaction is what keeps the fire going and allows it to spread. This type of reaction is called exothermic, which means that the chemical reaction is accompanied by a release of heat. So, the heat component of a wildland fire is always initiated by an external heat source, either natural or human-made, but once the fire starts, it supplies its own heat to keep going.

The fire triangle explains combustion in non-chemical terms. But, I'd like to talk a little about the chemistry of combustion as it relates to wildland fire. In this discussion, we know that the oxygen comes from the atmosphere, and let's assume that the fuel we are talking about is wood. So just what exactly is wood? Who (in the class) knows what wood is really made

- scientific language and symbols
- diagrams, charts, and other data displays
- mathematical expressions and processes (e.g., mean, median, slope, proportionality)
- clear, logical, and concise communication

5. Understand how scientific theories are used to explain and predict natural phenomena (e.g., plate tectonics, ocean currents, structure of atom).

Strand II: The Content of Science

Standard I (Physical Science): Understand the structure and properties of matter, the characteristics of energy, and the interactions between matter and energy.

9-12 Benchmark I: Understand the properties, underlying structure, and reactions of matter.

Grade 9-12 Performance Standards

Structure of Matter

5. Understand that matter is made of atoms and that atoms are made of subatomic particles.
9. Understand how the type and arrangement of atoms and their bonds determine macroscopic properties (e.g., boiling point, electrical conductivity, hardness of minerals).
10. Know that states of matter (i.e., solid, liquid, gas) depend on the arrangement of atoms and molecules and on their freedom of motion.

Chemical Reactions

12. Know that chemical reactions involve the rearrangement of atoms, and that they occur on many timescales (e.g., picoseconds to millennia).
13. Understand types of chemical reactions (e.g., synthesis, decomposition, combustion, redox, neutralization) and identify them as exothermic or endothermic.

Strand II: The Content of Science

Standard I (Physical Science): Understand the structure and properties of matter, the characteristics of energy, and the interactions between matter and energy.

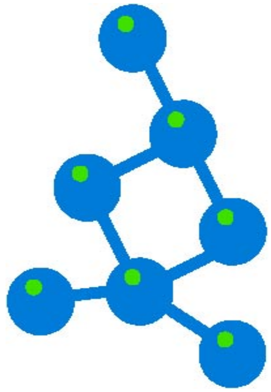
9-12 Benchmark II: Understand the transformation and transmission of energy and how energy and matter interact.

Grade 9-12 Performance Standards

Energy Transformation and Transfer

1. Identify different forms of energy, including kinetic, gravitational (potential), chemical, thermal, nuclear, and electromagnetic.
2. Explain how thermal energy (heat) consists of the random motion and vibrations of atoms and molecules and is measured by temperature.
3. Understand that energy can change from one form to another (e.g., changes in kinetic and potential energy in a gravitational field, heats of reaction,

of? (Take class answers.) The major structural components of wood are cellulose, hemicellulose, and lignin. Cellulose is a carbohydrate, which is an organic compound made up of only carbon, hydrogen and oxygen, and is produced in green plants by photosynthesis. The cellulose forms most of the walls of plant cells. Hemicellulose is a gummy carbohydrate that is less complex than cellulose. Lignin is an organic substance. Together, cellulose, hemicellulose and lignin form most of the woody tissues of trees. These substances also make up most of the weight of dry wood and comprise about 93 percent of wood. On an even more fundamental level, trees are approximately 50 percent carbon, 42 percent oxygen and 6 percent hydrogen.



Here is a question for you – Does wood burn? (Take responses from class.) Actually, wood never burns directly. Wood is considered a solid biomass fuel, which means that it is made up of living matter. The thermal degradation of wood is called pyrolysis. Wood fuel breaks down chemically when it is heated into a mixture of flammable gases and char. These two substances then combust under completely different chemical processes. Cellulose and hemicellulose mostly form flammable gases when they are heated. The lignin is what mostly forms the char. During pyrolysis (i.e. the burning of wood), the exact proportion of flammable gases to char is impossible to determine and is based on all kinds of variables such as temperature, fuel particle size, and the chemical makeup of the wood. Generally, however, the hotter the fire and the smaller the pieces of wood, the more flammable gases are produced. Whereas, the lower the temperature and the larger the pieces of wood, the more char is produced. That is why in a very hot fire, there will be less charred trees left standing because more of the original tree matter will have combusted and turned into gases.

As I said earlier, the organic compounds in wood when heated break down into flammable gases and char. The

hydroelectric dams) and know that energy is conserved in these changes.

4. Understand how heat can be transferred by conduction, convection, and radiation, and how heat conduction differs in conductors and insulators.
5. Explain how heat flows in terms of the transfer of vibrational motion of atoms and molecules from hotter to colder regions.

Strand II: The Content of Science

Standard II (Life Science): Understand the properties, structures, and processes of living things and the interdependence of living things and their environments.

9-12 Benchmark I: Understand how the survival of species depends on biodiversity and on complex interactions, including the cycling of matter and the flow of energy.

Grade 9-12 Performance Standards

Energy Flow in the Environment

5. Explain how matter and energy flow through biological systems (e.g., organisms, communities, ecosystems), and how the total amount of matter and energy is conserved but some energy is always released as heat to the environment.
6. Describe how energy flows from the sun through plants to herbivores to carnivores and decomposers.
7. Understand and explain the principles of photosynthesis (i.e., chloroplasts in plants convert light energy, carbon dioxide, and water into chemical energy).

Strand II: The Content of Science

Standard III (Earth and Space Science): Understand the structure of Earth, the solar system, and the universe, the interconnections among them, and the processes and interactions of Earth's systems.

9-12 Benchmark II: Examine the scientific theories of the origin, structure, energy, and evolution of Earth and its atmosphere, and their interconnections.

Grade 9-12 Performance Standards

Geochemical Cycles

9. Know that Earth's system contains a fixed amount of natural resources that cycle among land, water, the atmosphere, and living things (e.g., carbon and nitrogen cycles, rock cycle, water cycle, ground water, aquifers).
10. Describe the composition and structure of Earth's materials, including:
    - the major rock types (i.e., sedimentary, igneous, metamorphic) and their formation
    - natural resources (e.g., minerals, petroleum) and their formation.

flammable gases that are produced contain mostly carbon monoxide (CO), carbon dioxide (CO^2), some hydrocarbons and hydrogen (H^2). The flames you see in a fire are these flammable gases combusting. Also released with these gases are water and tar. (Tar contains organic compounds and airborne particles of tar and charred material.) The smoke you see coming off of a fire is this tar and the water, which is escaping as steam.

The properties of the char that is produced are highly dependent on the properties of the wood. When temperatures are high and there is enough oxygen, the carbon in the char burns to form carbon dioxide. When temperatures are low or there is insufficient oxygen, smoldering occurs, which causes a lot of smoke.

As this shows, the burning of the flammable gases, which is called flaming combustion, creates the flames of a fire, while the smoke you see comes from the tar and steam released in flaming combustion and also from the smoldering that occurs at lower temperatures.

What I have been explaining is in general terms. The process of wood combustion is extremely complicated, mostly because wood has a complex physical and chemical composition and is burned in an uncontrolled environment. Every fire is unique and even on one fire, the type of combustion that occurs will change from minute to minute and even from tree to tree.

Now, let's do a demonstration that shows some of the unique characteristics of pyrolysis, which is the burning of wood.

Activity

(Light a piece of dry wood that will burn with a flame and also leave a smoldering piece of char. Once the wood is burning on its own, remove the flame source. Observe the wood burning.)

Look closely at the surface of the wood where it is combusting. You will notice that the actual flame does not come in contact with the wood. That is because the wood itself is not burning. Instead, when the wood next to the flame is heated by the flame, it goes through pyrolysis, where the wood separates chemically into flammable gases and char. The flames you

SOCIAL STUDIES

Strand: Geography

Content Standard II: Students understand how physical, natural, and cultural process influence where people live, the ways in which people live, and how societies interact with one another and their environments.

9-12 Benchmark II-C: Analyze the impact of people, places, and natural environments upon the past and present in terms of our ability to plan for the future.

Grade 9-12 Performance Standards

2. Compare and contrast how different viewpoints influence policy regarding the use and management of natural resources.

9-12 Benchmark II-E: Analyze and evaluate how economic, political, cultural, and social processes interact to shape patterns of human populations, and their interdependence, cooperation, and conflict.

Grade 9-12 Performance Standards

6. Analyze how differing points of view and self-interest play a role in conflict over territory and resources (e.g., impact of culture, politics, strategic locations, resources).

LANGUAGE ARTS

Strand: Speaking and Writing for Expression

Content Standard II: Students will communicate effectively through speaking and writing.

9-12 Benchmarks II-C: Demonstrate competence in the skills and strategies of the writing process to inform and persuade

Grade 10 Performance Standards

2. Clearly articulate a position through the use of a thesis statement, anticipate and deal with counter-arguments, and develop arguments using a variety of methods such as:
   - examples and details
   - commonly accepted beliefs
   - expert opinions
   - quotations and citations
   - cause and effect
   - comparison and contrast reasoning
3. Differentiate among literal, figurative, and connotative meanings

Grade 11 Performance Standards

1. Use argument to:
   - interpret researched information
   - establish and defend a point of view
   - address concerns of the opposition
2. Synthesize and organize information from a variety

see above the wood are the flammable gases combusting in the process of flame combustion. This combustion gives off the light that we see as flame. The black, solid substance beneath the flame is the char. Also, above the flame you will see the smoke, which you now know is actually steam, tar and particulates. Now look at the char that no longer has a flame near it (i.e. the wood that has already been burned). Notice that this char is still hot and may even still be glowing red. By blowing on it, you can make it glow even brighter. This char is smoldering, which is combustion at a lower temperature. Smoldering causes a lot of smoke.

Activity

(Light piece of bark or something else that will smolder but not flame combust. Hold the flame source to the bark until the bark starts burning. Then, remove the flame source.)

Notice that when I remove the ignition source from this piece of bark that the flames immediately go out, but the part that was burned remains hot, glowing red and smoking. What you are seeing, like the wood earlier, is the bark combusting by smoldering. But, because there is no flame, there is no flame combustion. This bark is burning by smoldering. Remember that smoldering occurs at a lower temperature. Without the flame combustion, less of the actual wood is burned in the same amount of time. You may also notice that this smoldering stops rather quickly and the bark cools down a lot more quickly than the piece of dry wood we burned earlier. This is why ponderosa pines are considered fire resistant – because their bark is less conducive to burning. As long as a wildfire is of low enough intensity, or in other words is not too hot, the bark of the ponderosa pines will only smolder and not flame combust. Also, once the flames of the fire have passed, the combustion of the bark will usually stop before the living part of the tree is burned.

Lesson Continued

Okay, that's the chemistry of wood combustion in a wildland fire. As fire managers, it's important for us to understand how

of sources in order to inform and persuade an audience.

Forest Service Conservation Education Learner Guidelines

Program title: The Role of Chemistry in Fire Management
Target audience: High School Chemistry
Primary topic: Chemistry is fundamental to firefighting.

Length of program: 1 to 1.25 hours

Setting: indoors

Guidelines addressed are referenced here:

9-adult
I. Questioning and Analysis Skills
A1, A3
II. Knowledge of Environmental Processes and Systems
1. A1, B1, B2, C1
2. C5, D1, D2
3. C2
4. A1, A3, B1, B3, B4, C1, C2, C3, C4, D1
III. Skills for Understanding and Addressing Environmental Issues
1. A3, A4, C2, C3
2. D1
IV. Personal and Civic Responsibility
C1, D2, D3, D4

the chemistry works. We also go beyond that by applying this chemistry into techniques and science that we use on a daily basis to help us understand, manage, fight, and even predict wildland fire.

Note: Use this section as time and attention span allows. If not using it, read the paragraph in brackets [ ] only and then skip to next section titled "Lesson Continued." If using this section, skip the paragraph in brackets [ ] and continue with the next paragraph, which begins, "Certain people in the Forest Service … ."

[We use a system called the National Fire Danger Rating System to help us predict where wildland fires might occur and how intense these fires might be. You've all seen the little Smokey Bear signs that tell you the fire danger for the day, right? How do we come up with that fire danger rating? Does Smokey go out and sniff the air? No. It's based on science and chemistry. Every single day across the country, scientists and government workers are monitoring things like the weather, the winds and how dry the vegetation in our forests is for every section of wildland across the country. So, you can see – we don't just use science in the laboratory to study how different kinds of wood burn just for the fun of it, we actually use the information that we've learned every single day to help us predict and fight wildland fires.]

Certain people in the Forest Service and in other government agencies continually study how different types of trees and vegetation burn. They do this to better understand wildfire and to help us predict what a wildfire might do once it starts. But, beyond simply studying fire itself, many government agencies are now dedicated to studying the three components of the fire triangle to help us predict when and where wildfires might occur before they even start. This is what I'm going to talk about now – how we look at the weather, the climate, the terrain and the ecology of an area to help us predict wildfires so that we can have the people and resources in the right place at the right time ready to fight them.

You've all seen the little Smokey Bear signs that tell you the fire danger for the day, right? How do we come up with that fire danger rating? Does Smokey go out and sniff the air? No. It's based on science and chemistry, and here is how we do it. We use a system called the National Fire Danger Rating System. This system is run by the National Weather Service and is operational from Maine to California and from Florida to Alaska. It is a set of computer programs and mathematical equations that allow land management agencies to estimate the fire danger for today or tomorrow in a given area. For each day, the National Fire Danger Rating System characterizes the fire danger in an area by evaluating how bad a wildfire would be if one were to start that day in that area. These calculations are based on fuels, topography, and weather. You should recognize these three things as relating to our fire triangle. In this case, the oxygen and heat sides of our fire triangle are taken into consideration by looking at the topography of the area and the weather that day.

The fire danger rating for each day is based on science and chemistry.

The National Fire Danger Rating System gives us relative ratings on the potential growth and behavior of any wildfire. We use these ratings not only to tell us what rating to put on the Smokey Bear signs, but also to guide us in planning where to put our fire crews and how many firefighters to send to a fire once it starts. The system uses what are called indexes to calculate the fire danger ratings. These indexes are derived from three fire behavior components. The spread component or SC, the energy release component or ERC, and the ignition component or IC.

The ignition component is a number that relates to the probability that a fire will start if an ignition source is put into the forest. The IC can range from 0 when conditions are cool and damp to 100 on days when the weather is dry and windy. For example, on a day when the IC registers a 60, that means that about 60 percent of all ignition sources that come into contact with fuels in the forest will start a wildland fire. Ignition usually takes place in small, dead fuel, such as pine needles. Three things must happen for a fire to start. They are: 1. An ignition source must come into contact with the dead fuel. 2. The fuel particle must be dry. And, 3. The temperature of the fuel particle must be raised to the kindling point – the point at which wood will combust – which is about 380 degrees Celsius. Living material in the forest reduces the chances of ignition. So, the more dead trees that are in the forest, the better the chances that a fire will start. What do you think that means for our forest right now with all the trees that are brown? Moisture in dead wood will also hamper ignition. The NFDRS looks at the weather, temperature and relative humidity to help determine the moisture content of dead wood. Also, the warmer the dead wood is, the closer it is to its kindling point, which means the more likely a fire is to start. So, on hotter days, the fire danger will go up. It is the chemistry of wood combustion that we talked about earlier that is the basis for all of these calculations. All these considerations are put into a complex equation to determine the numerical IC rating.

The spread component is a number that looks at the effects of wind, slope and fuel properties in determining how fast a wildfire will spread. This rating is given in feet per minute. The SC uses wind speed, slope, fuel moisture and the amount of living vs. dead vegetation in an area to compute how much oxygen, heat and fuel are available to a fire. If a fire is moving uphill through a forest on a windy day, the fire can spread incredibly quickly. It is the chemistry of the fire triangle that forms the basis for these calculations.

The energy release component is the potential available energy per square foot of flaming fire at the head of the fire. In other words, the ERC looks at the amount and types of fuels available to a wildfire to determine how much fuel there is for the fire to burn. The more fuel to burn, the more intense the fire will be and the more energy it will release. The ERC varies widely depending on the type of fuel (i.e. the type of vegetation – grasses, trees, shrubs, etc.). Scientists who have studied the chemistry of how different types of wood burn have determined how to calculate the amount of energy that each type of fuel releases. It is this energy release that the ERC is measuring. The ERC is expressed in units of BTUs per square foot. (BTU = British Thermal Unit, which measures the amount of energy release necessary to raise the temperature of a pound of water by one degree Fahrenheit.)

The National Fire Danger Rating System has maps of the entire country that show both the topography (the terrain) as well as the type and amount of fuels (vegetation) on the land. Every day during fire season, the NFDRS uses these maps combined with up-to-the-minute weather observations to calculate the ratings of the SC, IC and ERC. Using these ratings, the NFDRS then computes an overall fire danger rating for every section of wildland across the country.

(Get NFDRS maps from their Web site – Show maps to the students)

The bottom line of this rating system is to help land management agencies prevent and put out wildland fire by helping them determine where and how to staff their firefighters. It is extremely important to try to catch wildland fires when they are still small. Once a fire has grown to a certain size, it becomes much more difficult to stop it. We use the NFDRS to try to anticipate fires so that a small fire doesn't become a catastrophic wildland fire.

Lesson Continued

So now that we understand some of the chemistry involved in burning, how do we actually go about putting out a fire? Well, that's all based on chemistry too. If you'll remember when I first talked about the fire triangle, I said that if one of the three components were missing, fire could not occur. Obviously, if there is no fuel (i.e. something to burn), there will be no fire. But also, if there is no oxygen, then the chemical process of burning cannot occur. Lastly, if there is not enough heat to either start or support a fire, then there will not be enough energy for the chemical process of burning to occur. So, to put out a fire, all we have to do is take away one of the three components of the fire triangle. We use a combination of techniques to try to take away these components from a fire. Once a fire is started, we can try to put water on the fuel to cool it down, thereby taking away the fire's heat. Or, we can cut down trees and remove vegetation in the fire's path to take away its source of fuel. Or, on some small fires, you can even beat the fire with a burlap sack or step on it to take away the air, thereby taking away the oxygen.

These aerial ignition ping-pong balls are based on chemistry. The plastic sphere of the ball is filled with a precise amount of potassium permanganate. The sphere then gets injected with ethylene glycol. When these two chemicals are combined, a chemical reaction takes place that produces a lot of heat. This heat quickly builds up to the point where a combustion reaction (i.e. burning) takes place.

Let's talk about one of the interesting techniques we use to manage a wildland fire. Maybe you can help me out – How can we get water to stick to the side of a house so that it will be protected when a wildland fire approaches? Any ideas? Well, years ago, as a wildfire was approaching a home, firefighters were faced with the problem of trying to keep the house wet while at the same time ensuring that they could get out of the way of the fire. Unfortunately, in the heat of a fire, water dries very quickly, and it is also hard to get water to stick to the walls of a house! Now, we use a relatively recent invention called fire foam. Fire foam is a sticky, puffy looking substance that we spray on structures that are in the path of a wildfire. The foam sticks to the walls and roof of a structure long after the firefighters leave. Also, it is designed to be extremely fire resistant so that in the best scenario, as the flames burn around the structure, the foam keeps the structure itself from catching on fire. A lot of chemical research and study into the chemistry of fire went into the design of fire foam. In fact, the chemistry behind fire foam is so complex and so important that the companies that make fire foam keep their ingredients and exactly how they make the foam a secret! Generally, though, fire foam does three things. First, it does something called "wetting" the water, which means that it reduces the surface tension of water. This allows the water to better penetrate surfaces. Second, it changes the properties of water so that it is better able to stick to surfaces. Finally, it makes the water foamy, which results in a thicker barrier between the fuel and the fire.

Let's watch a brief video clip to see some of these properties of foam.

Video

(Show NFES 2073 Introduction to Class A Foam, time 4:28 through 6:45.)

Lesson Continued

When it is not fire season, firefighters are still actively working to prevent wildland fires. One of the ways we do that is through prescribed burning. Prescribed burning removes fuels from the forest that could carry a wildland fire. So, it is like getting rid of one component of the fire triangle – fuel – long before a wildland fire has the chance to start. We can light prescribed burns from the ground or from the air. This is where that crazy ping-pong ball that I showed you earlier comes into play. Just like the fire foam, these aerial ignition ping-pong balls are based on chemistry. The plastic sphere of the ball is filled with a precise amount of potassium permanganate, which is an inorganic chemical oxidizer. Inorganic simply means that it does not contain carbon. And, oxidizer means that it easily gives up its oxygen atoms in a chemical reaction, which makes it great for use in combustion. The stuff that I injected into the ping-pong ball was ethylene glycol. When these two chemicals are combined, a chemical reaction takes place that produces a lot of heat. This heat quickly builds up to the point where a combustion reaction (i.e. burning) takes place. That is the fire that you saw.

To light a prescribed fire, we use a helicopter to drop these ping-pong balls onto the exact location that we want to burn. The ping-pong balls ignite just after hitting the ground. They easily burn hot enough to light the fuels on the forest floor on fire right where fire managers want the burn to take place.

Closing

I hope that you have learned a lot today about the importance of chemistry to wildland fire managers. Not only is it important for us to understand the chemistry of burning, but it is also important for us to use that knowledge of chemistry in predicting and fighting wildland fire.

Handout

No handout.

Supplies

- 2 aerial ignition ping-pong balls and materials necessary to ignite them
- Graphic rendering of fire triangle (or ability to draw it on a board)
- Piece of dry wood
- Piece of bark
- Lighter or other ignition source
- NFDRS maps of the country (only if this section is being used)
- NFES 2073 Introduction to Class A Foam, time 4:28 through 6:45